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DESIGN AND STRESS ANALYSIS OF MULTILAYER HIGH PRESSURE VESSELS BY USING FEM

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ABSTRACT

The limitations of single wall cylindrical shaped metallic vessels for restricting large volumes of high internal pressures has been recognized in process industries like chemical and petroleum industries. In process engineering as the pressure of the working liquid expands, increase in the thickness of the vessel planned to hold that liquid is an automatic decision. The addition in the thickness beyond a certain point has fabrication challenges as well as requests stronger material for the vessel development. Multilayer Pressure Vessels have extended the art of pressure vessel development and gave the process designer a reliable bit of equipment valuable in an extensive variety of working conditions for the issues created by the storage of hydrogen and hydrogenation processes.

In this Project "DESIGN AND STRESS ANALYSIS OF MULTILAYER HIGH PRESSURE VESSELS BY USING FEM" features of multilayered high pressure vessels, their advantages over mono block vessel are analyzed. The analysis is done by considering the S2 glass epoxy and E glass Epoxy materials in the multilayer pressure vessel. The Multilayer pressure vessel and solid wall pressure are analyzed in ANSYS, a versatile Finite Element Package for stresses created in them. The conclusions are drawn from the solid wall and multilayer pressure vessel by comparing theoretical and ANSYS values.

I. INTRODUCTION

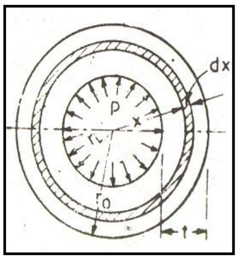
The pressure vessels are same as that of the containers or reservoirs which contains large amount of internal and external pressures. The storage of fluids under high pressures is done in Pressure vessel. The liquid being put away may experience a change of state inside the pressure vessels as if there should raise an occurrence of steam boilers or it may merge with different reagents as in chemical plants. Pressure vessels have wide applications in thermal and atomic power plants, chemical and process industries, in sea depths and space, and in water, steam, gas and air supply in industries. The material of a pressure vessel may be weak, for example, cast iron, or malleable, for example, mild steel.

II. HIGH PRESSURE VESSELS

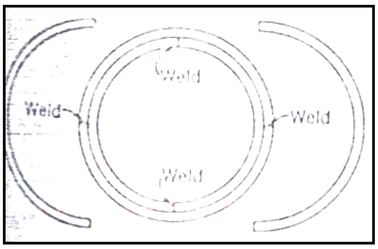
They are vessel with a fundamental base and a removable top head, and are generally outfitted with an inlet, heating and cooling system an agitator system. High Pressure vessels are used for a pressure capacity of 15 N/mm2 to a greatest of 300 N/mm2. These are essentially thick cylindrical vessels and hollow vessels, ranging in size from small tubes to a few meter diameters. Both the measure of the pressure and vessel included will manage the sort of construction utilized.

2.1 Methods for constructing high-pressure vessels

1. To construct a solid wall vessel from a solid rod of metal forging and boring process are used.
2. By bending a metal sheet with longitudinal weld a cylinder is formed.
3. Shrink fit development, the vessel is developed from two or more concentric shells, every shell progressively shrunk on from within outward. From economic and fabrication contemplations, the quantity of shells ought to be restricted to two.
4. By wire winding around a central cylinder a vessel is built. Under tension around cylinder a 6 to 10mm thick wire is wound.
5. A vessel created by wrapping a progression of sheets of moderately thin metal firmly round one another over a center tube, and holding each sheet with a longitudinal weld. Rings are inserted in the closures to hold the internal shell round while subsequent layers are incorporated. The liner cylinder is generally up to12 mm thick, while the resulting layers are up to 6 mm thick.



(a) Solid Wall Vessel



(b) Multi Layered Cylindrical Vessel

Fig.1 Types of High Pressure Vessels

III. LITERATURE SURVEY

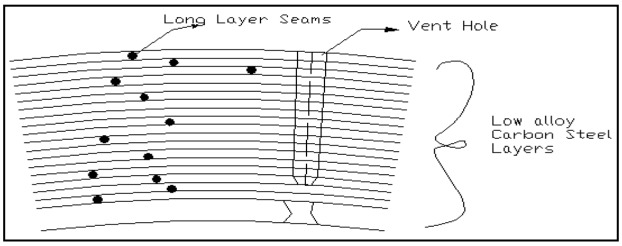
3.1 Multi - Layer Pressure Vessel for High Pressure Service

The importance of a well engineered vessel, manufactured with careful inspection and quality control methods, remain as the crucial factor for obtaining a safe, economical, and serviceable unit.

As early as 1890 Mr. Carl Schaeffer of Oberhausen, Germany, obtained a U.S. patent covering the multiple layer construction for “riveted” boilers and the like vessels. The patent is required for the ever-increasing tension of steam required for steam boilers, the damage imparted to thick sheet iron during forming and the unproportional cost of the thick plates. But from the early investigations, the patent was prompted by the current limitations of the solid wall constructions and was never widely accepted.

However, with advent of welding and the increase need for high-pressure vessels, designers in the 1930’s started to develop vessel concepts, which employed multiple layers of material for the vessel wall. Since that time thousands of multiple wall vessels have been put into service, both here and abroad, with an excellent record of performance. There are a number of multilayer vessel concepts available to the user today. The wicker type vessel, developed in Germany, uses a corrugated metal tape or ribbon spiral wound around an inner core cylinder. Spiral grooves to match the corrugations of the tape are first machined into the outer surface of the inner cylinder. Then, layer at a time, until the full wall thickness is reached.

Each succeeding layer mechanically locks the underlying layers together through the meshing of corrugations in the tape or ribbon. Therefore, the vessel hoop stresses are borne by the ribbon acting in tension, and the longitudinal stresses are taken by the ribbon acting in shear across the corrugations. A few of these vessels have been imported from the states. In Japan, another layer vessel concept has been developed wherein individual vessel "cans" or cylinders are manufactured by coiling a continuous material of the light gauge material around an inner cylinder until the proper wall thickness is reached. The individual cans are then welded together to complete the vessel shell.



IV. FACTORS CONSIDERED FOR HIGH PRESSURE VESSELS DESIGN

In chemical process industries the high pressure utilization opened up another field to designers. This relatively new procedure started in the industrial synthesis of ammonia salts from its elements and with the procedure for the cracking of oil.

High pressure vessels presently reached out up to 350 MPa.

For designing high pressure vessels main factors to be considered are:

- Limitations in dimensions like Length and Diameter.
- Pressure and temperature like operating conditions.
- Physical properties and cost of the available materials.
- Reactants and products corrosive nature.
- Failure theories.
- Forging, welding or casting depending on type of construction.
- Fabrication methods.
- Fatigue, Brittle failure and Creep.
- Cost-effective considerations.

Different codes representing the strategies for the design, fabrication, inspection, testing and operation of vessels have been produced, somewhat as a safety measure. These methods outfit gauges by which any state can be guaranteed or the wellbeing of weight vessels introduced inside of its limits. The particulars in these codes were initially based upon the details produced for steam boilers. Section VIII of ASME Boiler and Pressure Vessel Code, 1956 is the code utilized for unfired pressure vessels.

V. SOLID WALL PRESSURE VESSEL

A solid wall vessel incorporates a single cylindrical shell, with closed ends. In perspective of high internal pressure and enormous thickness the shell is considered as a "thick" cylinder. If all else fails, the physical criteria are managed by the proportion of measurement to wall thickness and the shell is made as thick cylinder, if its wall thickness surpasses one-tenth of inside diameter. A solid wall vessel is besides termed as Mono Block pressure vessel.

5.1 Design of Multilayer High Pressure Vessel

Multi layer vessels are developed by wrapping a progression of sheets over a main tube. The development includes the utilization of a few layers of material, normally with the purpose of quality control and optimum properties. Multi layer development is utilized for higher pressures. It gives inbuilt safety, uses material economically, no stress relief is required. For corrosive applications the inward liner is made of extraordinary material and is not considered for strength criteria. The outer load bearing shells can be made of high tensile low carbon alloys. Multi layer vessels are built up by wrapping a series of sheets over a core tube.

5.2 Introduction to S 2 Glass

High-quality glass, carbon or other propelled filaments are utilized as a part of utilizations requiring more prominent quality and lower weight. S-sort glass is for the most part high-quality glass in the United States, R-glass in Europe and T-glass in Japan. In 1960s for military applications S-glass were produced, and for business applications a lower cost adaptation, S-2 glass was created.

High-quality glass has apparently higher measures of silica oxide, aluminum oxide and magnesium oxide than E-glass. S-2 glass is around 40-70% more grounded than E-glass.

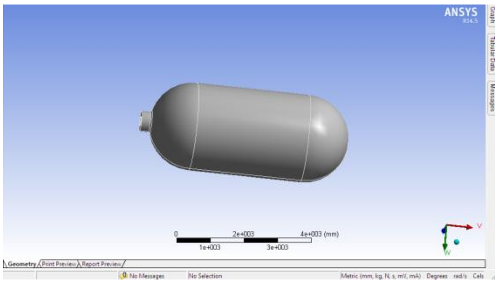
5.3 Finite Element Analysis

FEA is the functional utilization of the finite element method (FEM), which is utilized by architects, and scientists to scientifically model and numerically understand extremely complex structural, liquid, and multiphase issues. FEA programming can be used in extensive variety of businesses, yet is most generally utilized as a part of the aeronautical, biomechanical and locomotive industries.

A finite element (FE) model contains an arrangement of points, called "nodes", which frame the state of the design. Joined with these nodes are the finite elements themselves which frame the finite element mesh and contain the material and basic properties of the model, characterizing response of it in specific conditions. The density of the finite element mesh may differ all through the material, contingent upon the foreseen change in stress levels of a specific part. Areas that experience high changes in stress for the most part require a higher mesh density than those that experience little or no stress variation. Purposes of interest may incorporate crack purposes of beforehand tried material, fillets, corners, complex point of intersect, and high-stress regions.

5.3.1 Structural Analysis of Pressure vessel

Model of pressure vessel:



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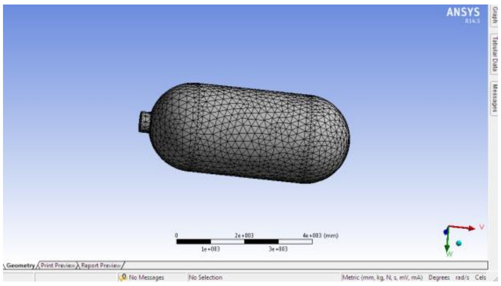
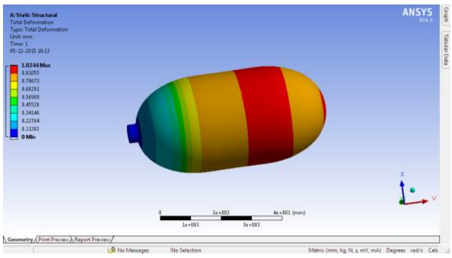
Meshed model:

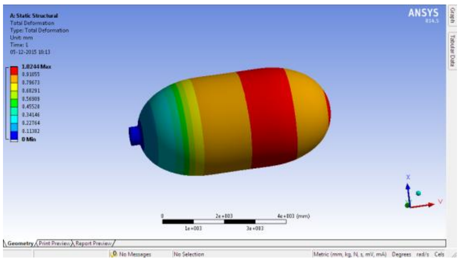


5.3.2 Material type: Steel

Total Deformation

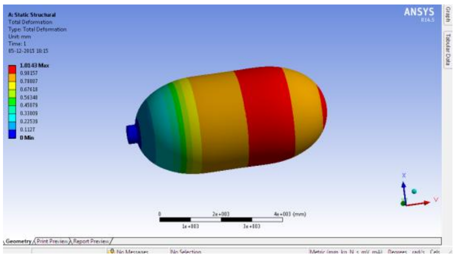


Equivalent Stress:

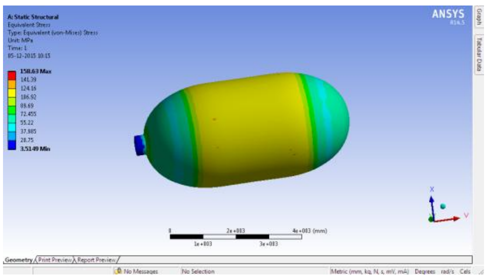


5.3.3 Material type: Liner material

Total deformation:

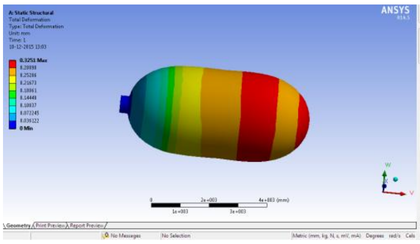


Equivalent stress:

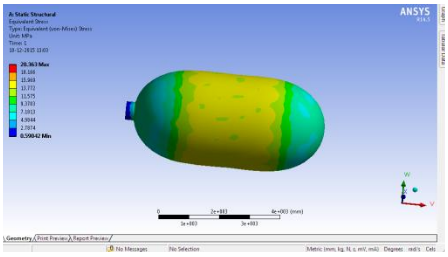


5.3.4 Material type: S2 Epoxy

Total Deformation:

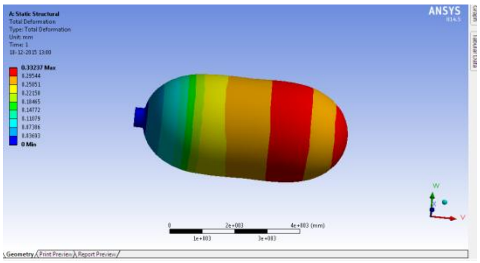


Equivalent stress:

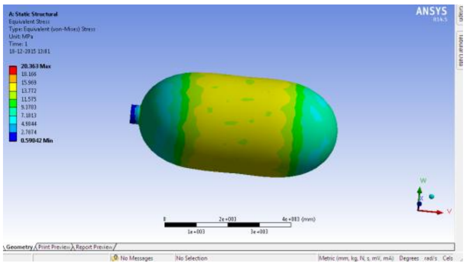


5.3.5 Material type: E Glass

Total Deformation:



Equivalent stress:



VI. RESULTS AND DISCUSSION

SINGLE LAYER			MULTI LAYER		
	DISP (mm)	STRESS (N/mm^2)		DISP (mm)	STRESS (N/mm^2)
STEEL	0.738338	144.38	**STEEL**	2.784	169.062
			S2 GLASS	0.3251	20.43
			E GLASS	0.33237	20.363

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VII. CONCLUSION

Solid wall pressure vessels are extensively used now-a-days. The huge difference of weight is observed by introducing the multi layered vessels. Here S2 Glass epoxy and E Glass epoxy are the materials used for analysis of multilayer pressure vessels.

The usage of multilayer pressure vessel decreases the weight as well as the material cost required to manufacture. Decreasing the weight and also cost is the main aspect of the designer. Multi layered vessels are compared to solid vessels with respect to the stresses developed. The most important aspect of the designer is to minimize the stress concentration developed. The effective usage of material during the fabrication is also observed.

By observing, the vessels are favored to work under conditions of high temperature and high pressures. The usage of multilayer pressure vessels is having more advantages than single wall pressure vessels.

By using composite material S2 Glass epoxy and E Glass epoxy in place of steel, decreases the overall weight of multilayered vessels. And also by analysis it is proved that using E glass Epoxy andS2 glass epoxy is also safe since the analyzed stress value is less.

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